Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) Data transmission apparatus ~~comprising a first transmit interface for transmitting a data stream comprising a sequence of fixed-size cells~~ for processing one or more high-rate data streams carrying data cells and delivering the high-rate data streams over data busses provided by a mid-plane having a limited number of signal conductors, the apparatus ~~to a receiver, the first transmit interface~~ comprising:

[[a)]] a first demultiplexer ~~connected to receive the data stream and to split the data stream by delivering the cells in rotation~~ for dividing data of one high-rate data stream into *N* sub-streams ~~a plurality of *N* transmit channels~~ so that each ~~transmit channel~~ sub-stream carries every N^{th} cell of the one high-rate data stream, the first demultiplexer configured to stagger transmission of cells in the sub-streams in time with respect to one another;

[[b)]] for each ~~channel~~ of the *N* sub-streams, a data transmitting device for serializing the data from the sub-stream and transmitting the serialized data in one or more serial data connections over said mid-plane to a data receive interface ~~connected to receive the cells of the transmit channel and to output the cells on one or more data connections carrying data in a first direction to a receiver~~;

[[c)]] a first transmit control circuit connected to the data transmitting devices of the *N* sub-streams

and configured to insert flow control signals into one or more of the sub-streams, the first transmit control circuit configured to selectively enable and disable the data transmitting devices in response to first receiver enable signals received over said mid-plane from the data receive interface, ~~the transmit control circuit configured to cause the transmitting devices to output the cells in sequence with the commencement of transmission of cells on sequential transmit channels staggered in time relative to one another by a time difference ΔT~~ whereby cell integrity and sequencing is maintained at said data transmission apparatus, and each of said sub-streams carries the cells that are routed to it by the first demultiplexer at a rate that is N times lower than a data rate of the high-rate data stream.

2. (Canceled)

3. (Currently Amended) ~~The apparatus of claim 2 comprising a first receive interface for receiving a data stream, the first receive interface comprising.~~ Apparatus according to claim 1 comprising:

a plurality of data receive devices each connected to receive a sub-stream of data comprising data incoming on one or more serial connections provided by the mid-plane;

[[a)]] ~~a plurality of deserializer devices for receiving one or more serial streams of cells in each of a plurality of receive channels~~ for each of the data receive devices, a corresponding buffer configured to receive fixed-length data cells carried in the corresponding sub-stream; and,

[[b)]] a first receive control circuit configured to determine a sequence of arrival of the cells ~~and to place the cells onto a bus in the sequence of arrival~~.

4. (Currently Amended) The apparatus of claim 3 wherein ~~one or more of the receive channels carries a flow control signal,~~ the first receive control circuit is configured to provide ~~the~~ flow control ~~signal~~ signals to the first transmit control circuit and the first transmit control circuit is configured to inhibit the output of cells ~~on~~ by one or more of the ~~channels~~ data transmit devices in response to the received flow control ~~signal~~ signals.

5. (Currently amended) The apparatus of claim 4 wherein the first receive control circuit is configured to demultiplex the flow control ~~signal~~ signals from the ~~stream of cells in one of the receive channels~~ corresponding sub-stream.

6. (Currently amended) ~~The apparatus of claim 3~~ Data transmission apparatus comprising a first transmit interface for transmitting a data stream comprising a sequence of fixed-size cells to a receiver, the first transmit interface comprising:

a first demultiplexer connected to receive the data stream and to split the data stream by delivering the cells in rotation into a plurality of N transmit channels so that each said transmit channel carries every N^{th} cell;

for each said transmit channel a data transmitting device connected to receive the cells of the transmit channel and to output the cells on one or more data connections carrying data in a

first direction to a receiver, wherein the data transmitting device comprises a serializer device and the data connections comprise serial data connections; and,

a first transmit control circuit connected to the data transmitting devices, the first transmit control circuit configured to cause the transmitting devices to output the cells in sequence with the commencement of transmission of cells on sequential transmit channels staggered in time relative to one another by a time difference ΔT;

the apparatus comprising:

a first receive interface for receiving a data stream, the first receive interface comprising:

a plurality of deserializer devices for receiving one or more serial streams of cells in each of a plurality of receive channels; and,

a first receive control circuit configured to determine a sequence of arrival of the cells and to place the cells onto a bus in the sequence of arrival

wherein the first receive interface comprises a buffer associated with each of the deserializer devices, each of the buffers of a capacity sufficient to hold a plurality of cells, wherein the receive control circuit is configured to issue a flow control signal when a buffer has a remaining capacity of Q cells, with $Q \geq 1$ and the first transmit control circuit is configured to transmit the flow control signal with the serial data to a second receive interface at a receiver.

7. (Original) The apparatus of claim 6 wherein the first transmit control circuit is configured to multiplex the flow control signal with the serial data in one of the transmit channels.

8. (Currently Amended) ~~The apparatus of claim 2~~ Data transmission apparatus comprising a first transmit interface for transmitting a data stream comprising a sequence of fixed-size cells to a receiver, the first transmit interface comprising:

a first demultiplexer connected to receive the data stream and to split the data stream by delivering the cells in rotation into a plurality of *N* transmit channels so that each said transmit channel carries every N^{th} cell;

for each said transmit channel a data transmitting device connected to receive the cells of the transmit channel and to output the cells on one or more data connections carrying data in a first direction to a receiver, wherein the data transmitting device comprises a serializer device and the data connections comprise serial data connections; and,

a first transmit control circuit connected to the data transmitting devices, the first transmit control circuit configured to cause the transmitting devices to output the cells in sequence with the commencement of transmission of cells on sequential transmit channels staggered in time relative to one another by a time difference ΔT;

wherein the first transmit interface is located on a line card having an interface for receiving the data stream, the apparatus comprises a receiver on a second card, and the serial data connections comprise data lines

extending between the line card and the second card through a midplane.

9. (Currently Amended) The apparatus of claim 8 wherein the receiver comprises a second receive interface for receiving a data stream, the second receive interface comprising:

a) a plurality of deserializer devices for receiving a the serial data in each of the channels; and,

b) a second receive control circuit configured to determine a sequence of arrival of cells in the serial data and to place the cells onto a bus in the sequence of arrival.

10. (Original) The apparatus of claim 9 wherein the second receive interface comprises a buffer associated with each of the deserializer devices, each buffer of a capacity sufficient to hold a plurality of cells, wherein the second receive control circuit is configured to issue a flow control signal when a buffer has a remaining capacity of Q cells or fewer, with Q ≥1, the second card comprises a transmitter connected to transmit the flow control signal to the line card and the first transmit control circuit is configured to inhibit transmission of cells on at least a channel corresponding to the buffer which has a remaining capacity of Q cells or fewer in response to the flow control signal.

11. (Original) The apparatus of claim 10 wherein the transmitter on the second card comprises a second transmit interface for transmitting a second data stream comprising a sequence of fixed-size cells to the line card, the second transmit interface comprising:

a) a second demultiplexer connected to receive the data stream and to split the data stream by delivering the cells in rotation into a plurality of *N* channels so that each channel carries every *N*th cell;

b) for each channel a serializer device connected to receive the cells of the channel and to output the cells as serial data on one or more serial data connections to the line card;

c) a second transmit control circuit connected to the serializer devices, the second transmit control circuit constructed to cause the serializer devices to output the cells of the second data stream in sequence and staggered in time relative to one another by a time difference ΔT.

12. (Currently Amended) Data transmission apparatus comprising:

a) means for carrying a data stream comprising a sequence of cells ~~in~~ having an order;

b) demultiplexing means for assigning each of the cells of the data stream to one of a plurality of channels;

c) transmitting means for transmitting the cells in each channel to a receiver by way of signal conductors in a mid-plane; ~~and,~~

d) control means for commencing the transmission of individual cells to the receiver, in the order, at times staggered relative to one another by a time difference ΔT that exceeds a worst case inter-channel difference in latency for transmission of cells from the transmitting means to the receiver by way of the mid-plane; and,

e) receiving the cells in the order at the receiver.

13. (Cancelled)

14. (Currently Amended) The data transmission apparatus of claim [[13]] 12 comprising means for receiving a plurality of serially transmitted cells in a plurality of channels and means for determining an order of arrival of the plurality of cells.

15. (Currently Amended) The data transmission apparatus of claim [[1]] 12 comprising a first receive interface for receiving a data stream, the first receive interface comprising a plurality of receiving devices each for receiving a stream of cells in one of a plurality of channels and, a first receive control circuit configured to determine a sequence of arrival of the cells and to place the cells onto a bus in the sequence of arrival.

16. (Currently Amended) The data transmission apparatus of ~~claims~~ claim 15 wherein the first receive interface is adapted to receive in the data stream a first direction flow control signal and the first transmit control circuit is connected to receive the flow control signal and adapted to selectively enable or inhibit the transmission of cells by one of the data transmission devices in response to the flow control signal.

17. (Original) The data transmission apparatus of claim 16 wherein the first receive interface is adapted to generate a second direction flow control signal and the first transmit control circuit is adapted to cause one of the data transmitting devices to output the second direction flow control signal.

18. (Original) A telecommunications switch comprising a plurality of line cards, a switching fabric, a plurality of fabric interface cards connected to the switching fabric and a midplane providing a plurality of data lines connecting the line cards and the fabric interface cards, the telecommunications switch comprising at least one bidirectional interface connecting one of the line cards and one of the fabric interface cards;

the bidirectional interface carrying a first sequence of data cells in a data stream received at the line card in a first direction from the line card to the corresponding fabric interface card and a second sequence of data cells in a second direction from the fabric interface card to the line card;

the bidirectional interface comprising: a first demultiplexer connected to receive the first data stream and to split the first data stream into a plurality of *N* first direction channels so that each first direction channel carries every *N*th cell;

for each first direction channel a serializer device connected to receive the cells of the first direction channel and to output the cells as serial data on one or more serial data connections extending through the midplane to the fabric interface card;

a first transmit control circuit connected to the serializer devices, the transmit control circuit configured to cause the serializer devices to output the cells in sequence order with the commencement of transmission of cells on different first direction channels staggered in time relative to one another by a time difference ΔT;

a plurality of deserializer devices at the fabric interface card, the deserializer devices connected to receive and deserialize the serial data on the serial data connections;

a first direction receive control circuit connected to detect an order of arrival of cells on the serial data connections and to place the cells into a received data stream in the order of arrival;

a second demultiplexer at the fabric interface card and connected to receive the second data stream and to split the second data stream into a plurality of N second direction channels so that each second direction channel carries every Nth cell;

for each second direction channel a serializer device connected to receive the cells of the second direction channel and to output the cells as serial data on one or more serial data connections extending through the midplane to the line card;

a second transmit control circuit connected to the serializer devices, the transmit control circuit configured to cause the serializer devices to output the cells in sequence order with the commencement of transmission of cells on different second direction channels staggered in time relative to one another by a time difference ΔT;

a plurality of second deserializer devices at the line card, the deserializer devices connected to receive and deserialize the serial data on the serial data connections; and,

a second direction receive control circuit connected to detect an order of arrival of cells on the serial data connections and to place the cells into a received data stream in the order of arrival.

19. (Cancelled)

20. (Currently Amended) The method of claim [[19]] 24 comprising serializing the data of each channel before transmitting the data of the channel.

21. (Currently Amended) The method of claim [[19]] 24 wherein there are *N* channels and assigning each of the cells of the data stream into one of a plurality of channels comprises assigning the cells to the channels in rotation so that each channel carries every N^{th} cell.

22. (Original) The method of claim 20 wherein transmitting the serialized data for each channel comprises transmitting a plurality of streams of serial data.

23. (Cancelled)

24. (Currently Amended) ~~The method of claim 23 comprising,~~ A method for transmitting a data stream comprising a sequence of fixed-size cells to a receiver, the method comprising:

assigning consecutive cells of the data stream into different ones of a plurality of channels;

simultaneously transmitting to the receiver data on each of the channels while staggering transmission of consecutive ones of the cells in time relative to one another by a time difference ΔT

receiving a flow control signal and inhibiting the transmission of cells in at least one of the channels in response to the flow control signal; and,

upon the transmission of cells in one of the channels being inhibited, waiting until the

transmission of cells on the channel is not inhibited and then commencing the transmission of a cell an integer multiple of ΔT after the time at which transmission of a previous cell commenced on the channel.

25. (Original) The method of claim 20 comprising, for at least one channel, multiplexing flow control signals with the serialized data before transmitting the serialized data.

26. (Original) The method of claim 20 wherein the sequence of cells comprises an OC-192 data stream.

27. (Original) The method of claim 20 comprising receiving the serialized data at a receiver, deserializing the received data, identifying an order of arrival of cells at the receiver and placing the cells on a signal bus in their order of arrival.

28. (Original) The method of claim 27 comprising, for each channel, monitoring a number of cells which have arrived at the receiver and have not yet been placed on the signal bus and suspending transmission of cells on the channel if the number exceeds a threshold.

29. (Original) The method of claim 28 wherein suspending transmission of cells on the channel comprises issuing a flow control signal.

30. (Currently Amended) A method for transmitting a sequence of cells, in order, from a transmitting device to a receiving device, the method comprising:

assigning each of the cells to one of a plurality of channels ~~in rotation~~, each of the channels having a recurring cell transmit time, the cell transmit times for successive channels staggered relative to one another by amounts exceeding any inter-channel differences in skew and latency;

in each channel, transmitting the cells in sequence to the receiving device over one or more serial data connections and commencing transmission of each cell only at the cell transmit time for that channel; and,

receiving the transmitted cells at a receiving device in the same order that the cells were transmitted.

31. (Currently Amended) The method of claim 30 comprising, ~~receiving and~~ deserializing the transmitted cells at ~~a~~ the receiving device, and detecting an order of arrival of the cells at the receiving device.

32. (New) The method of claim 30 comprising receiving a plurality of cells substantially simultaneously at the transmitting device and assigning each of the plurality of cells to one of the plurality of channels in rotation.

33. (New) Apparatus according to claim 3 comprising means for altering a status of second receiver enable signals corresponding to each of the data receive devices based on a status of the corresponding buffer.

34. (New) Apparatus according to claim 3 comprising a mechanism for generating a second receive enable signal upon the arrival in one of the buffers of a second last cell that the buffer can hold.

35. (New) Apparatus according to claim 1 wherein the sub-streams are staggered in time by ΔT, and ΔT is greater than a maximum total skew due to the mid-plane, the data transmitting device and the data receive interface.

36. (New) Apparatus according to claim 1 wherein the flow control signals include a clock signal, a parity signal, and a start of cell signal.